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The Nappe Structure of the North Sporades in Greece

The Glossa Unit of Skopelos

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IN SCIENTIFIC RESEARCH

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Abstract

The Glossa unit of Skopelos (North Sporades) has been previously attributed to the pre-Mesozoic basement of the Pelagonian zone. The rock assemblage of the Glossa series (alternation of calc-schists, phyllites and greenschists with some lenses of metabasalts and cipolinos) differs, however, widely from the Pelagonian schists, but is identical with that of Eohellenic outliers on neighbouring islands. This interpretation has been affirmed in detail by new petrographical and geochemical data and, moreover, by the observation that the Glossa unit is clearly overthrust onto the Pelagonian schists, on Skopelos.

Zusammenfassung

Die Glossa-Einheit auf Skopelos (Nord-Sporaden) wurde bisher dem vormesozoischen Kristallin des Pelagonikums zugerechnet. Nach ihrem Stoffbestand (Wechsellagerung von Kalkschiefern, Phylliten und Grünschiefern mit Einschaltungen von Metabasalten und Glimmermarmoren ist dies jedoch sehr unwahrscheinlich; dagegen stimmt sie sehr gut mit eohellenischen Deckschollen auf den Nachbarinseln überein. Diese Interpretation wird durch neue petrographische und geochemische Daten im Detail gestützt, vor allem aber durch die Beobachtung, daß die Glossa Serie das Pelagonikum mit klarem Überschiebungskontakt überlagert.

1. Introduction

Within the past decades, geological exploration of Greece has progressed quite quickly, and our knowledge of this country is now remarkably better than of the neighbouring regions of southeastern Europe and Turkey. Fairly clear concepts pertaining to the Hellenide nappe structure of the continental regions of Greece have been published. However, several factors interfere with the extension of these concepts to the Aegean islands. For example the Aegean Sea represents a major hindrance when attempting to uncover palaeogeographical and structural evidence relevant to understanding the connection between geological features of mainland Greece and Anatolia. Also geologists have difficulties in reaching some of the islands.

The recent discovery of quite new geological units and even nappe tiers on Aegean islands has thrown new light on the subject and demands a better comprehension of the orogenic connections between continental Greece and Anatolia. With this paper and ongoing studies the authors hope to contribute some regional results to these problems.

The Greek island of Skopelos belongs to the North Sporades archipelago situated in the North Aegean Sea (fig. 1). These islands are part of the internal Hellenides. HARDER et al. (1983), JACOBSHAGEN and WALLBRECHER (1984) and JACOBSHAGEN (1986) have proposed the following definition of the islands' tectonic structure into geological stockworks (from top to bottom):

Skyros nappe,
Mesoautochthonous sediments,
Eohellenic nappe,
Pelagonian nappes

Of these stockworks, only the Skyros nappe, which is confined to one outlier on the island of Skyros, is composed of sediments. The others were strongly overprinted by a Mesohellenic (Eocene) metamorphism.

The orogenic history of these units has been infered to be the following: During the Early Cretaceous, the Eohellenic nappe composed of an ophiolitic suite with hemipelagic sediments was obduced from the Tethys to the W onto the Pelagonian carbonate platform. The latter was part of the Adria micro-continent. This thrusting was succeeded by uplift, weathering and erosion, which partly cut through the Eohellenic nappe and deeply penetrated the Pelagonian underground.

During the Albian this relief was sealed by conglomerates, which were followed by rudist limestones and finally by flysch of Maastrichtian to (?) Palaeocene age; this post-Eohellenic sequence was called Mesoautochthonous. The origin of the Skyros unit and the age of its overthrust are still unknown, but it must be connected with post-Eocene tectonic events.

The geological exploration of Skopelos was initiated by VIRLET (1834). Observations concerning stratigraphy and bauxite deposits were published by PHILIPPSON (1901), RENZ (1955), PAPASTAMATIOU and MARINOS (1938, 1940) and PAPASTAMATIOU (1963). GUERNET (1971) was the first to present a geological overview with a sketch map of the island. On this basis, structural investigations were carried out by JACOBSHAGEN and SKALA (1977) and JACOBSHAGEN et al. (1976). Since 1981, D. Matarangas has mapped the whole island to the scale 1:25.000 and carried out detailed research on problems of stratigraphy (MATARANGAS and SKOURTSIS-CORONEOU 1989), tectonic structures, metamorphism, petrography, and geochemistry.

According to the publications mentioned above, three geological units can be dis-

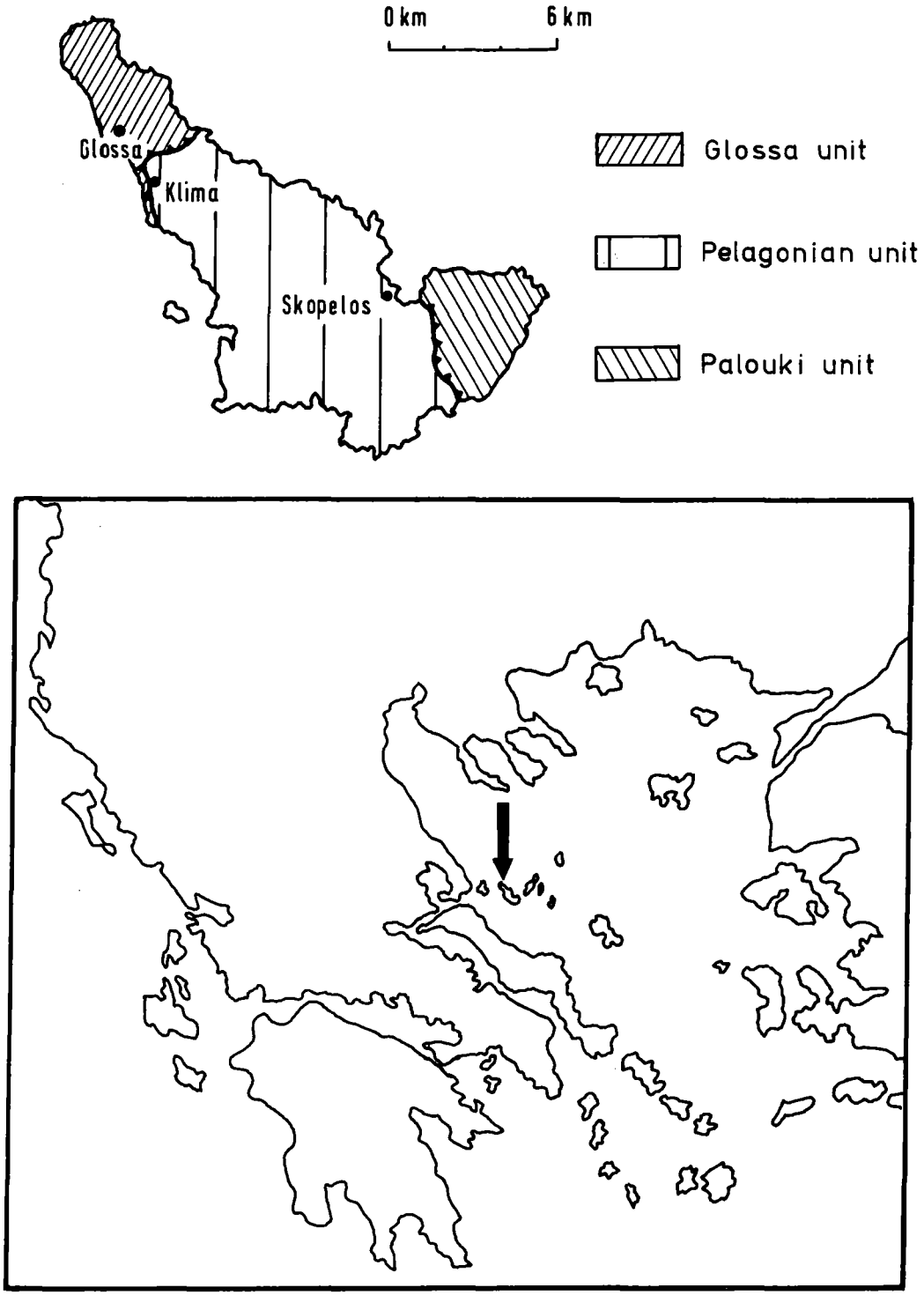


Fig. 1: Geographical position (A) and geological subdivision (B) of Skopelos.

tinguished on Skopelos: The Glossa unit to the NW, a central unit of Pelagonian character, and the Palouki unit in the SE (fig. 1 B).

The stratigraphic sequence of the central unit is shown on fig. 2 A. It is built up by a basal schist series with carbonate lenses which were formerly believed to be of Upper Palaeozoic and Lower Triassic age. MATARANGAS and SKOURTSIS-CORONEOU 1989) could, however, date the upper part of these schists to Ladinian-Carnian. The thick dolomite series ontop of the schists was found to be of Norian-Rhaetian age. The dolomites are unconformably overlain by ophiolitic relics, bauxites and conglomerates which are succeeded by rudist limestones. The latter are covered by flysch.

The Palouki unit consists of an intercalation of thin bedded, dark schists, partly containing chert lenses and grey or brown sandstone layers. These rocks are followed by rudist limestones and flysch. GUERNET (1970) attributed the Palouki series to the Palaeozoic, whereas KELEPERTSIS (1973, 1974) and JACOBSHAGEN and SKALA (1977) have assumed an Upper Cretaceous age. New observations and fossil findings will provide more information in the near future (MATARANGAS, in preparation).

The Glossa unit comprises greenschists, phyllites, calc-schists and cipolinos (PAPASTAMATIOU 1963, JACOBSHAGEN and SKALA 1977). A stratigraphical column is presented on fig. 2 B.

The Glossa series has been designated by all previous authors to the basal schists of the Pelagonian sequence of the central unit. Thus, it was believed to belong to the crystalline basement of the Pelagonian, in spite of significant differences to all outcrops of pre-Mesozoic Pelagonian rocks on the North Sporades (Skiathos, Skiros) and on the Magnesian peninsula of continental Greece.

New observations and results, which are briefly summarized on the following pages, suggest, however, another interpretation.

2. The Glossa unit

2.1 Petrography and metamorphism of the Glossa series

The Glossa unit of northwestern Skopelos is built up by a volcanosedimentary series, which consists of an alternation of calc-schists, phyllites and greenschists, the latter being of metavolcanic origin. Locally, this Glossa series includes also lenses of Fe-Mn-quartzites. Cipolinos in a thickness of up to 40 m are characteristic of the upper part of the series. The regional distribution of these rocks is shown in a geological sketch-map (fig. 3). The main petrographical characteristics of all these members of the Glossa series are listed below:

Metasediments

Calc-schists: Greyish rocks, strongly deformed by foliation and folding in mesoscopic and microscopic scale. Changing degree of recrystallisation.

Mineral assemblage: White mica, chlorite, calcite, titanite, leucoxene, Fe-oxides and -hydroxides.

Phyllites: These very fine-grained schists consist mainly of white mica (sericite), chlorite, quartz, ± albite, ± epidote, ±

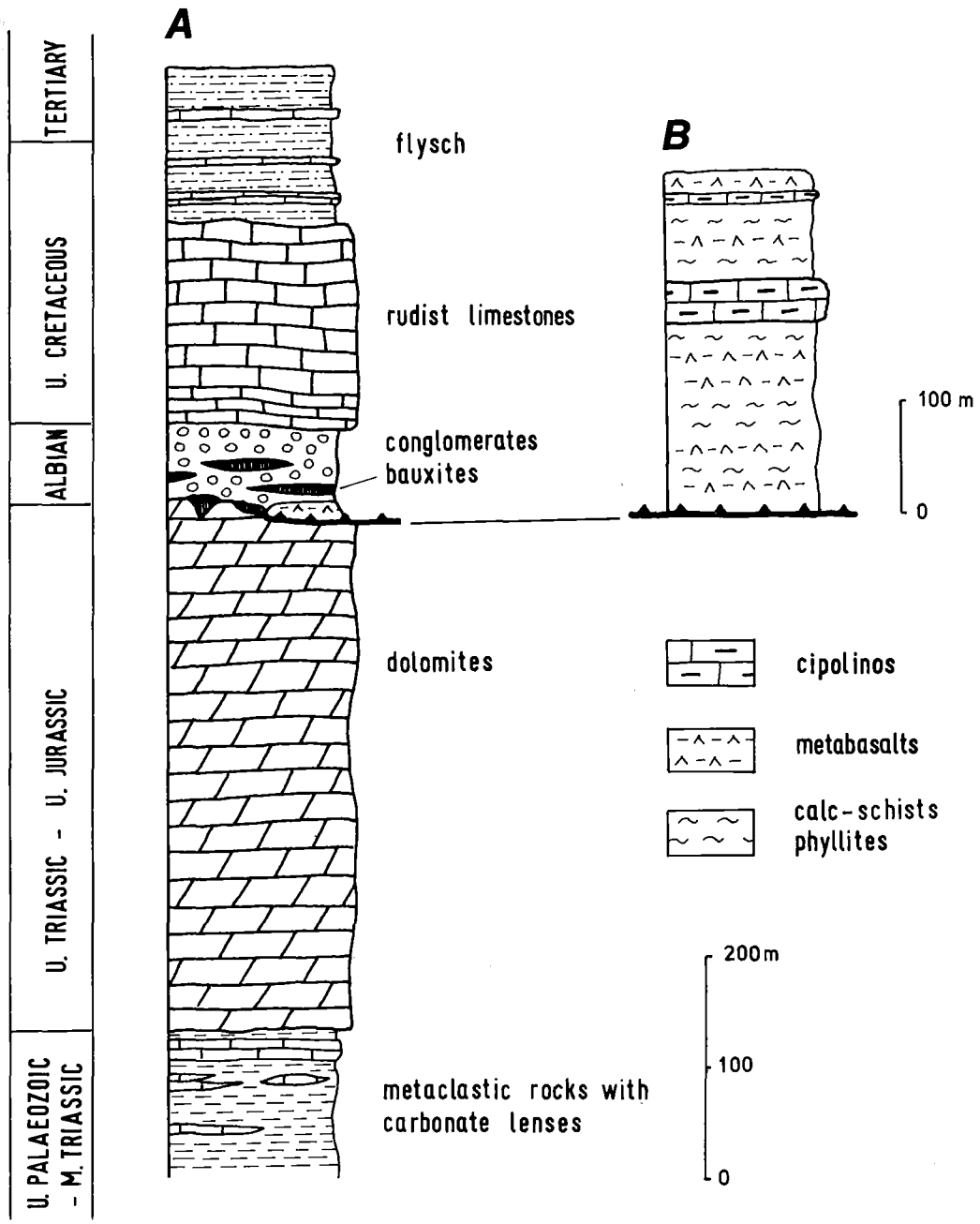


Fig. 2: Stratigraphical columns for the central unit (A) and the Glossa unit (B) of Skopelos.

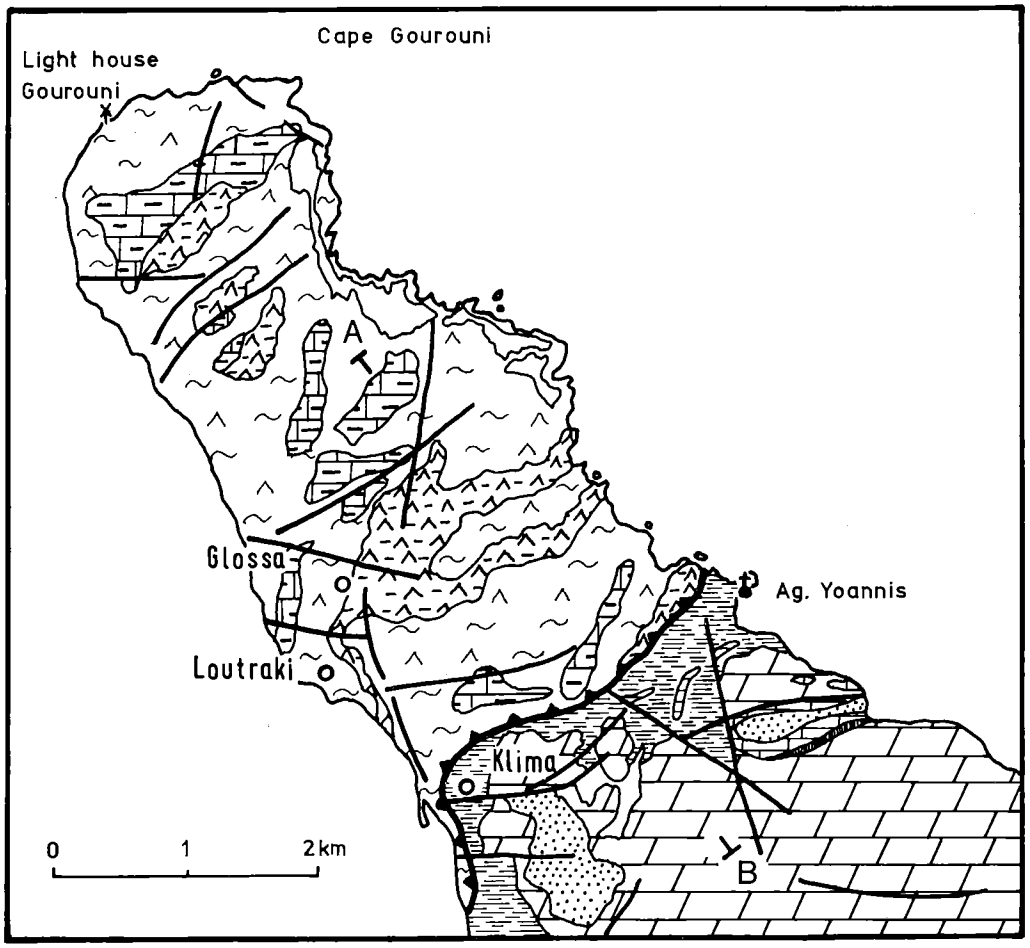


Fig. 3: Geological sketch-map of the Glossa unit, northwestern Skopelos

leucoxene, and Fe-oxides and -hydroxides. Accessory constituents are, furthermore, tourmaline, apatite, and zircon.

cipolinos or cipoline marbles: Within these medium-grained rocks the prevailing calcite crystals are associated with quartz and feldspars to a certain amount. Parts of the cipolinos show a thin lamination, which is caused by layers of chlorite, white mica, leucoxene, epidote, and tourmaline.

Fe-Mn-quartzites: Locally, lenses of Fe-Mn-quartzites are observed with diameters up to 10 m. The predominating minerals quartz and Fe-Mn-oxides and -hydroxides, are accompanied by piemontite, chlorite, and albite.

Metavolcanic rocks

Greenschists: Although strongly deformed by foliation and microfolding and, moreover, altered by metamorphic recrystallisation and sometimes also by weathering, parts of the greenschist clearly show a volcanic origin. These parts are fine- to medium-grained and exhibit predominantly a subophitic texture. Amygdaloidal structures displaying epidote, chlorite and quartz or only quartz showing a mortar structure are, however, frequent.

Mineral assemblage : In general, only a secondary, metamorphic mineral association can be observed: plagioclase (albite and oligoclase), actinolite, epidote (clinozoisite/zoisite + epidote), chlorite, white mica, quartz, titanite, leucoxene. Calcite and Fe-oxides and -hydroxides are also frequent. The primary paragenesis is, however, represented by relics of pyroxene (augite) crystals in a few samples. Moreover, crystals of amphibole have been frequently observed with a core of actinolite together with hornblende and only actinolite in the outer parts.

The observations described above allow the classification of the greenschists as metabasalts.

Geochemical studies carried out by MATARANGAS and KALOGEROPOULOS (in preparation) suggest that the metabasalts have been N-type MORB produced by small degrees of partial melting and subsequent fractional crystallization of pertinent ferromagnesian mineral phases. They were probably emplaced in a geotectonic setting comparable with a marginal or even an oceanic basin.

The secondary minerals of the metabasalts testify also to the degree of metamorphism of the Glossa series: According to WINKLER (1979), the paragenesis

chlorite + zoisite/clinozoisite + actinolite + quartz

defines low grade metamorphism for mafic metamorphic rocks. According to JACOBSHAGEN and SKALA (1977), this metamorphism happened during the Mesohellenic orogeny in Eocene times.

2.2. Regional affinities of the Glossa series

When discussing the regional affinities of the Glossa series, we have to repeat that it is completely different from the pre-Mesozoic basement of the Pelagonian nappes. Within the crystalline complex of Thessaly, the latter is e.g. formed by gneisses, amphibolites, micaschists, phyllites and metagranitoids. These rocks

were transformed by Variscan metamorphism. Ontop of these crystalline rocks, a metaclastic series composed of greywackes, conglomerates, breccias and schists follows, which was called the Skiathos series by JACOBSHAGEN and SKALA (1977). In the North Aegean region, this series crops out on the Magnesian peninsula (JACOBSHAGEN et al. 1976), on the Sporades islands of Skiathos and Skyros (HARDER et al. 1983), and on Lesbos (JACOBSHAGEN and SKALA 1977). On the top, the metaclastic series is overlain by a thick sequence of Pelagonian marbles. Thus, it is not probable that the Glossa series was part of the Pelagonian basement.

A comparison of the rock sequences found on neighbouring islands and land masses with the Glossa unit on Skopelos reveals that the Glossa rock assemblage is in fact present within relics of the Eohellenic nappe on the Magnesian peninsula (WALLBRECHER 1983) and on the North Sporades islands of Skyros, Alonnisos, Kyra Panagia and Skantsoura (HARDER et al. 1983). Even details like the piemontite bearing Fe-Mn-quartzite lenses described by WALLBRECHER (1983) from the Magnesian peninsula correlate well. On Skyros, calc-schists, cipolinos, marble lenses, phyllites, and mafic metavolcanics equivalent to the one found on Skopelos form the bulk of the Eohellenic rocks. Here, they are accompanied also by breccias and metagreywackes and, most significantly by serpentinites and ophiolitic melanges. Ophiolites occuring only as small incoherent lenses are also common at some of the mentioned localities. In a large area of northeastern Skyros, they are even missing.

It should be mentioned that small relics of Eohellenic ophiolites were detected within the central unit of Skopelos between the Upper Triassic-Jurassic dolomites and the Mesoautochtonous Upper Cretaceous series, e.g. in Panormos (JACOBSHAGEN and SKALA 1977) north of the town of Skopelos, and below the overthrust of the Palouki unit.

Thus, the lithology allows the Glossa unit of Skooelos to be designated to the Eohellenic nanoe.

2.3. Tectonic position and deformation of the Glossa unit

The lithological comparison of the Glossa series with the Eohellenic nappe of Skyros led us to reinvestigate the relationships and contacts between the Glossa series and the Pelagonian Triassic schists of the central unit of Skopelos. For this particular field work, the surrounding of the chappel of Ag. Yoannis at the northeastern coast yield the best exposures.

SE of the chappel, a primary transition from red or greyish schists with carbonate lenses to the dolomite marbles of the Pelagonian sequence can be observed on the southern flank of an ENE striking anticline. On the northern flank of this antikline the Pelagonian schists (Werfenian according to PAPASTAMATIOU 1963) are nearly conformably overlain by greenschists of the Glossa series with a dip of about 40° to the NNW (fig. 4). The contact between both series is clearly of tectonic origin: The upper parts of the Pelagonian schists are intensely folded, and also the lowermost Glossa greenschists are extremely tectonized. Narrow folds of dm-seize with torn limbs pass over to a fabric of small tectonic lenses, laterally. Along the contact, they are completely crumbled by cataclasis. Due to these observations we have inter-

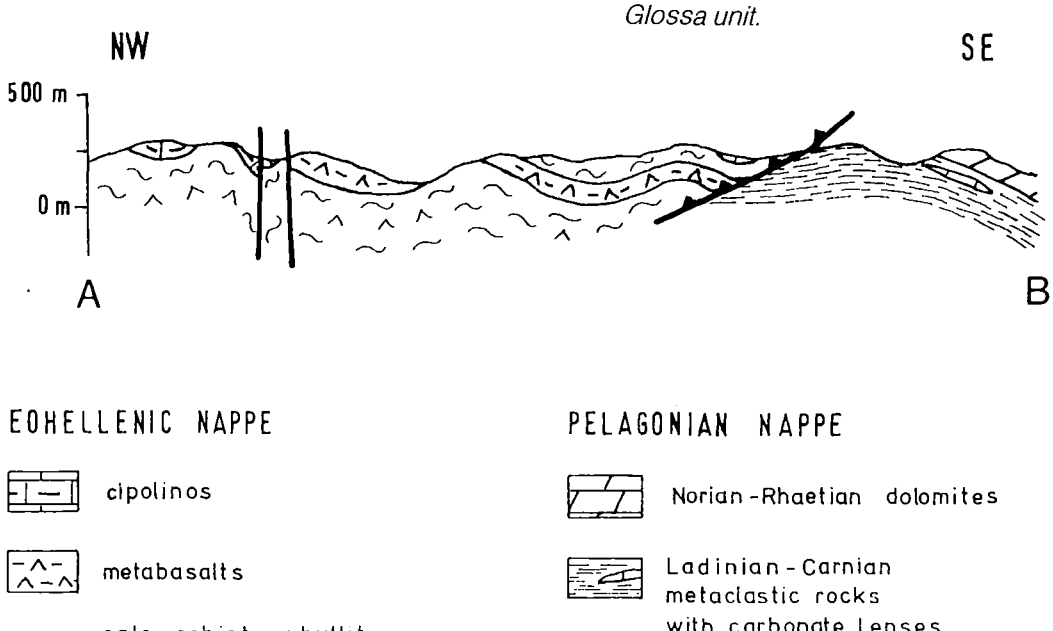
preted the contact as a low-angle overthrust. This overthrust can be followed across the island to the southwestern coast near Klima. Thus, we may state that the Pelagonian schists and the Glossa series are not only different from a lithological point of view, but are also separated by an overthrust. The tectonical superposition of the Glossa series finally affirms our interpretation that it was part of the Eohellenic nappe.

Furthermore, it is difficult to explain why the Pelagonian dolomite marbles are missing between the Pelagonian schists and the Glossa series on the northwestern flank of the anticline. Either Pelagonian folds must have been sheared during the Eohellenic obduction; or the overthrust observed was a product of the Mesohellenic collision in Eocene times.

Tectonically, the Glossa unit is deformed by open mega-folds (fig. 4), but internally it exhibits narrow folds, the axes of which can be distributed to three systems with maxima in the directions WNW, NNE, and ENE. The first two systems originated probably synchronously, while the ENE axes might be a little younger. On fig. 5 it is obvious that along the western coast NNE axes predominate. But approaching the northern end of Skopelos (near the Gourouni light house), the direction of fold axes turns to the ENE. These observations are in good harmony with the results of JACOBSHAGEN and SKALA (1977). These authors already stated that all fold structures of the North Sporades were formed during the Eocene because the Mesoautochthonous flysch shows the same deformation.

Finally, it may be mentioned that the Glossa unit is cut by young fractures striking to the NE and to the NW, respectively. The same direction of fractures can also be observed within the other tectonic units of Skopelos.

Fig. 4: Geological cross-section of the Glossa unit.



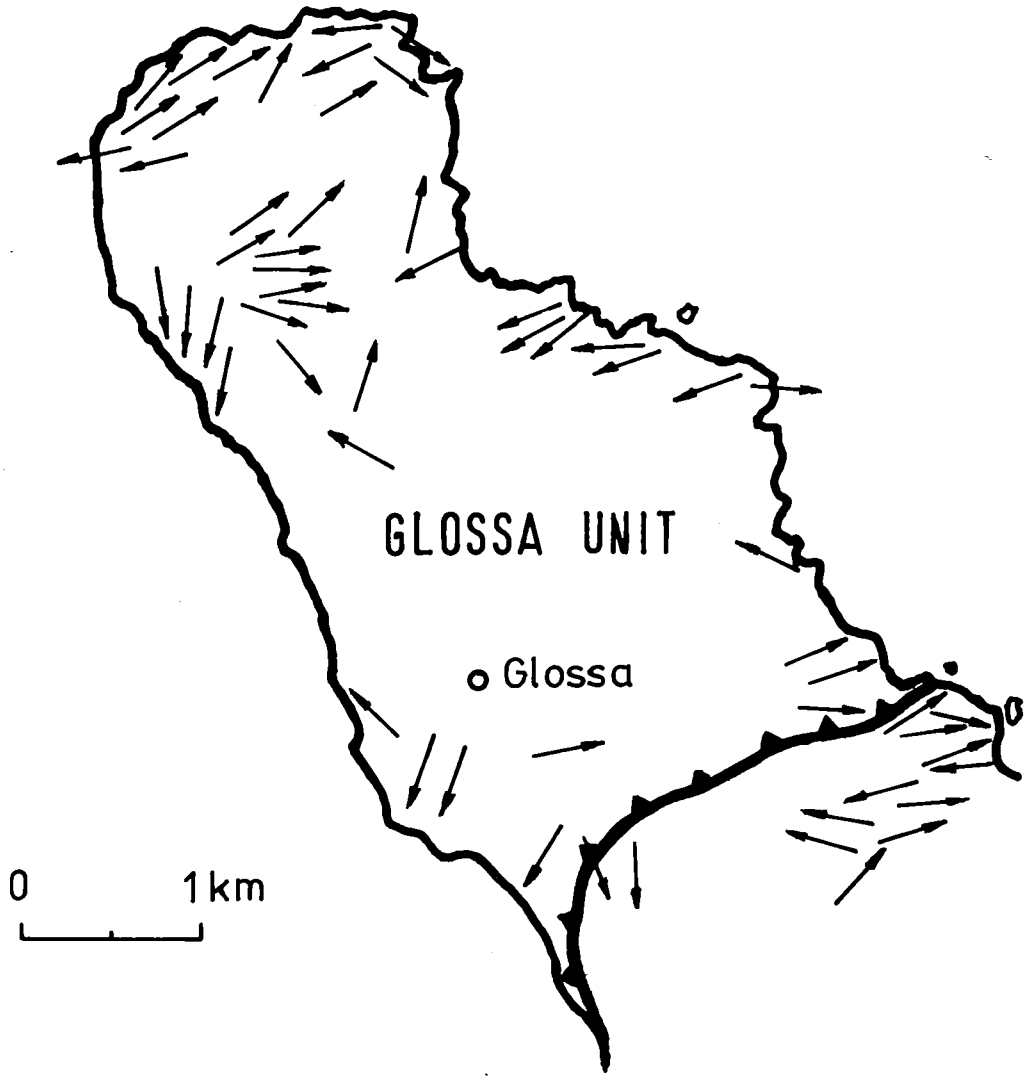


Fig. 5: Distribution of fold axes within the Glossa unit.

3. Conclusions

Our new field observations as well as lithological comparisons and the petrological and geochemical data from the Glossa series testify clearly to an Eohellenic origin of the Glossa unit, and allow us to discard the previous view of it belonqinq to the pre-Mesozoic basement of the Pelagonian nappes. The lithological character of the Glossa metasediments points to a hemipelagic or even pelagic origin. We want to draw special attention to the piemontite-bearing quartzites, which have been interpreted to be meta-radiolarites by WALLBRECHER (1983). Our interpretation is affirmed by the geochemical data from the metabasalts which might have originated within a marginal or even oceanic basin.

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